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(54) Title: HF DATA COMMUNICATIONS SYSTEM WITH NETWORK MANAGEMENT		
(57) Abstract A method of network management for a radio communications network comprising a plurality of stations each of which includes a transceiver and control means therefor, the transceiver and control means of the respective stations being substantially similar, and the stations being arranged to communicate directly with any other station, the method comprising: assigning at least one control channel of predetermined frequency to the network for transmitting network control signals between the stations; assigning to each station which may assume control a ranking position in a priority list of stations which may assume control of the network; each station monitoring the control channel or channels to determine whether control has been established by another station, and if so accepting control signals from such other station, and if control has not been established, the station transmits at a time determined by the ranking position of the station control signals on said control channel or channels for assuming network control.		

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HF data communications system with network management.

This invention relates to a high frequency (HF) communications network comprising a plurality of stations each of which may intercommunicate with any other station.

HF is generally recognized as the frequency range 2-30 MHz. However for the purposes of this specification, this term is intended to cover any frequency up to 30 MHz and may include frequencies above 30 MHz. The term is intended to designate a type of radio transmission usually involving ionospheric reflection, from the F-layer, the maximum usable frequency usually being somewhat less than 30 MHz.

Commercial and military systems are known employing HF transmission between a large number of ground stations located over a limited geographical area, for example, an army may possess portable transceivers carried on vehicles or as "man-packs" which rely on HF data transmissions. In emergency situations, not all transceivers may be in operation and it may be important to know precisely how many stations are operative and establish communication between those operative stations.

In addition whilst HF stations have traditionally required skilled operators, skilled operators are in short supply and proposals have been made to automate certain call establishment procedures so that unskilled operators may operate the transceivers. Thus in IEE Conference Proceedings 1985 no. 245, "Real time frequency management in an embedded microcomputer", E.T. Clarke, a

microcomputer which is normally present in portable transceivers is employed to store a model of the ionosphere over a limited geographical area so that predictions of usable channel frequencies may be made automatically.

However there has been no previous proposal for an automatic system for establishing network control in a network of stations where the precise number and location of the stations is initially unknown.

It is therefore an object of the present invention to provide in an HF telecommunications network, an automated system for establishing network control which may be operated by unskilled operators.

The present invention provides a method of network management for an HF communications network comprising a plurality of stations each of which includes a transceiver and control means therefor, said transceiver and control means of the respective stations being substantially similar, and the transceivers being arranged to communicate directly with any other station, wherein the system comprises:

- assigning at least one control channel of predetermined frequency to the network or transmitting control signals between the stations;

- assigning to each station which may assume control a ranking position in a priority list of stations which may assume control of the network;

- each station being arranged to monitor the control channel or channels to determine whether control has been established and

each station being arranged to transmit at a predetermined time, the time of transmission being predetermined according to the ranking position of the station, control information on the channel or channels for assuming control of the network.

Thus in operation of the invention, when a station wishes to go 'on air', it will monitor the control channels which are of frequencies known to the station to determine whether control signals are being transmitted by a station in control of the network. If the station detects such signals which will be transmitted at regular intervals, say every half-hour, then the station will decode the control information for initialisation and synchronisation information and a list of channel frequencies on which it may attempt data transmission.

If the station wishing to go 'on air' does not detect control signals on the control channels, then the station will at a predetermined time transmit control signals on the control channels for assuming network control. This information will include initialisation and synchronisation information which will be received by other stations lower in the priority list for accepting instructions from the station seeking control. Such station will then undergo a procedure for establishing a list of channel frequencies on which data may be transmitted. This procedure is described more fully in our copending application < > (F20257). Having established a list of channel frequencies of which communications may take place and a list of stations forming the network, these lists are transmitted on the control channels to the other stations in the network and communications may thereafter take place.

Although the invention is particularly applicable to data communication where data is transmitted in digital form, nevertheless analog voice transmission is envisaged.

In the case of a station which goes 'on-air' after a station has assumed control, if the late entrant has a higher assigned rank than the station in control, this is ignored and the station in control will remain in control.

Thus it may be seen the invention provides the following features:-

- (i) Establishing control when the availability of particular radio stations is uncertain.
- (ii) Providing affiliation for an uncertain number of radio stations during network initialisation and subsequent network operation.
- (iii) Distributing network control information regularly and reliably in both normal and disturbed radio propagation conditions.

The invention defines a procedure for selecting a network control device or station (CS) from an ordered list supplied by the user. It further describes how the chosen CS determines which radio stations are available for initial affiliation to the network and how the CS provides late entry facilities for stations which subsequently wish to affiliate to the network. The invention also defines a means for distributing control and engineering data to stations in the network.

The radio network is deployed with the User defined list of possible control stations (CS). The list is arranged according to a

ranking order and each possible CS is given a time period in which to initialise the network. The first possible CS in the list is given the first time period, the second possible CS the second time period and so on.

A possible CS will assume control in its time period if the network has not already been initialised by a higher ranking or earlier station in the list (i.e. the higher ranking stations can be assumed to be unavailable).

The network is also deployed with every radio station being programmed with a common set of engineering frequencies. All stations will scan these engineering frequencies listening for transmissions from a CS until affiliation to the network is achieved. The CS will in the first instance use each of these engineering frequencies in turn to send probe transmissions to a small subset of the possible network stations. This set of stations transmit replies in the timeslots defined by the CS probe transmissions on those engineering frequencies on which the probes were received. The CS will assess these replies and choose a preferred subset of engineering frequencies on which to contact the remaining network stations.

The CS next sends a probe transmission on each of the preferred engineering frequencies addressed to all network stations. Those stations which receive these probes will transmit replies to the CS in the timeslots defined by the CS probe transmissions. The CS will collect the replies and list the originating stations as being affiliated to the network.

On completion of the initialisation procedure the CS will distribute engineering data via broadcast transmissions on the same

preferred selection of engineering frequencies. The engineering data may include for example:

- A list of affiliated stations
- Timing data for network synchronisation
- Frequency management information
- Network control instructions

Individual stations within the network will combine the broadcasts of engineering data in order to assemble an error free set of data whenever possible.

During normal network operation the CS will transmit update engineering data at regular intervals according to a known time schedule. For example a schedule which repeats on an hourly basis may be used if disturbed propagation conditions are expected. A proportion of these transmissions will be on a subset of the engineering frequencies so that these may be intercepted by stations joining the network as late entrants. Late entrants will transmit affiliation messages to the CS.

Stations already affiliated to the network will be scanning a known set of channels awaiting traffic calls. Thus engineering transmissions will be made on these channels at known times to provide rapid updating facility for these stations.

In all cases the engineering transmissions will be transmitted on more than one frequency so that receiving stations may combine versions received in order to assemble an error-free set of data whenever possible.

A preferred embodiment of the invention will now be described with reference to the accompanying drawings, wherein:-

Figure 1 is a block diagram of a radio station of the HF data telecommunications network according to the invention;

Figure 2 is a timing diagram showing assigned time slots for transmission to determine the control of the network;

Figure 3 is a timing diagram showing control signals which are transmitted during a procedure for assuming control by a station; and,

Figure 4 is a timing diagram showing control information which is transmitted during regular intervals to the other stations.

Referring now to figure 1 of the drawings, each station of the network includes a transceiver and a control means therefor which are substantially the same. Thus each station comprises a transmitter 10 and a receiver 12 coupled to an HF aerial 14. An oscillator 16 is provided of variable frequency coupled to transmitter 10 and a receiver 14. A microcomputer 22 comprising a central processor 24 and a memory 26 has an address/data bus 28 coupled to a modulator 18 and a demodulator 20 via buffers 30 and 32. The data is fed in digital form from buffer 30 to modulator 18 and modulator 18 is operative to modulate the data onto the carrier frequency by oscillator 16 in any suitable format, e.g. pulse modulation, frequency shift keying or phase shift keying. The data transmission rates are low, ~ 100 bauds⁻¹ in order to provide for reliable transmission. Encoding techniques are provided for detection and correction of errors and these techniques are described in our copending application < > (F20256).

Demodulator 20 operates in the opposite manner to modulator 18 to demodulate information from an incoming data stream and to

provide this information to buffer 32. Central processor 24 includes a status register 40 for indicating whether the network is under control of another station. The processor includes a further register 42 which stores the location of the station in a priority list in ranking order of stations which may assume control of the network.

Memory 26 is divided into sections of which section 44 is a section recording control procedures, section 46 is a section storing information as to the available frequency channels for information transmission, section 48 is a section for storing predetermined frequency channels for control purposes, and section 50 is a section for storing the propagational state of the ionosphere in digital form and routines for updating this information. A keyboard 51 and display 52 are provided and a station clock 54, accurate to wrist-watch accuracy.

Thus in operation say upon initial start up of the system, an unskilled operator will switch on the system via a keyboard 51 and a display 52 will indicate to the operator the various operations to be performed to start up the station. The receiver 12 will monitor the predetermined control channels for control signals which may be provided by a control station already in operation. If the receiver 12 detects control signals then these are decoded and interpreted by central processor 24 which thereupon flags status register 40 to indicate that a control station is functioning and that the station should accept control information. Thus the station operates in a slave mode and received information as indicated in Figure 3. This information includes synchronisation information for synchronising station clock 54 and information which defines the usable 'pool' of

frequency channels for data transmission. Following the transmission of control information, there follows a series of time slots in which stations which have received the control information will transmit acknowledgement signals.

If however upon initial switch on of the system, the station does not detect within a predetermined period any control information transmitted over a control channel, then the station will assume that no control station is in operation and will accordingly initiate a control capture routine in which the address stored in register 42 is monitored and according to the ranking order of the station the station will transmit at a predetermined time as determined by clock 54 and within a predetermined time slot as indicated in figure 2 control signals over a control channel which will serve to initialise and synchronise other stations as subservient to the control station.

The transmission sequence is shown in figure 3. Initially the control station transmits probe signals over a set of calling channel frequencies $f_1 \dots f_n$ to a subset of test stations 1, 2, 3 and replies are received in predetermined time slots over the channel frequencies. Depending on the replies received, the control station chooses a set of preferred channel frequencies f_1, f_2 and transmits a further set of probe signals on these channels to all stations. The stations which are operative will reply in time slots $S_1 \dots S_N$ on frequencies f_1, f_2 . The control station will then draw up a list of stations forming part of the network and distributes on a selected channel frequency control information, comprising initialisation, synchronisation, frequency

management information. Replies are received from the station in time slots S1 ... SN.

Once having assumed control, the radio station undergoes an automatic procedure as is fully described in our copending application < > (F20257) for determining a list of channel frequencies in which data transmission can reliably be made.

Once having assumed control the control station regularly transmits information on each selected control channel in turn as shown in Figure 4 comprising packets containing, control, sync frequency management and parity check, and replies are made in time slots S1 ... SN.

CLAIMS

1. A method of network management for a radio communications network comprising a plurality of stations each of which includes a transceiver and control means therefor, the transceiver and control means of the respective stations being substantially similar, and the stations being arranged to communicate directly with any other station, the method comprising:

assigning at least one control channel of predetermined frequency to the network for transmitting network control signals between the stations;

assigning to each station which may assume control a ranking position in a priority list of stations which may assume control of the network;

each station monitoring the control channel or channels to determine whether control has been established by another station, and if so accepting control signals from such other station, and if control has not been established, the station transmits at a time determined by the ranking position of the station control signals on said control channel or channels for assuming network control.

2. A method as claimed in claim 1, wherein the network is an HF data communications network.

3. A method as claimed in claim 1 wherein when said control signals are transmitted by the control station at regular intervals on each of the control channels in turn.
4. A method as claimed in claim 3 wherein said control signals include initialisation and synchronisation information and information as to the channel frequencies which may be used for communications, and replies are made by the stations forming the network in predetermined time slots.
5. A method as claimed in claim 1 wherein each station forming part of the network transmits an acknowledgement signal in a predetermined time slot in response to receipt of a control signal.
6. A method as claimed in claim 1, wherein when a station seeks network control, a first control signal sequence is transmitted and replies are awaiting from a predetermined subset of stations, and if these replies are satisfactory, a second control signal sequence is transmitted to all stations and replies are awaited for defining those stations which are affiliated to the network, and engineering data is then transmitted to all affiliated stations including a list of affiliated stations, timing data and channel frequency information for information transmission.
7. A method of network management for an HF data communications network substantially as described with reference to the accompanying drawings.

8. A radio communications network comprising a plurality of stations each of which includes a transceiver and control means therefor, the transceiver and control means of the respective stations being substantially similar, and the stations are arranged to communicate directly with each other, wherein for network control, each station includes means storing the frequency value of at least one control channel of predetermined frequency on which network control signals are transmitted, means storing a ranking position value in a priority list of stations which may assume network control, and processor means for automatically controlling the station in a network control procedure in which the station monitors the control channel or channels and issues control signals on the control channel or channels at a predetermined time if no control signals are monitored.

9. A radio communications network as claimed in claim 8 and substantially as described with reference to the accompanying drawings.

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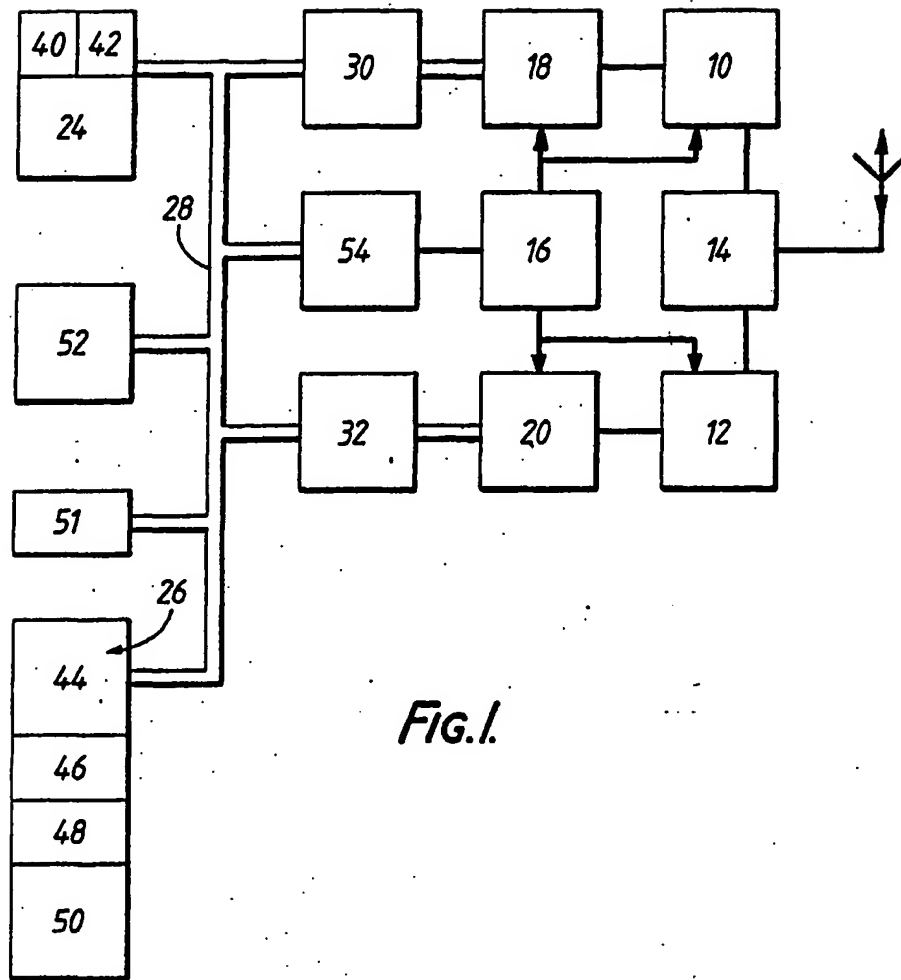
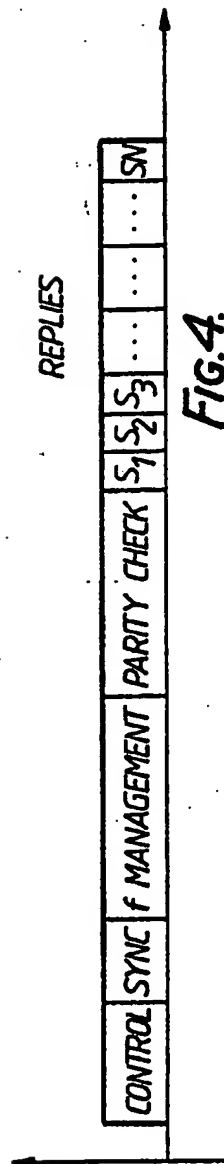
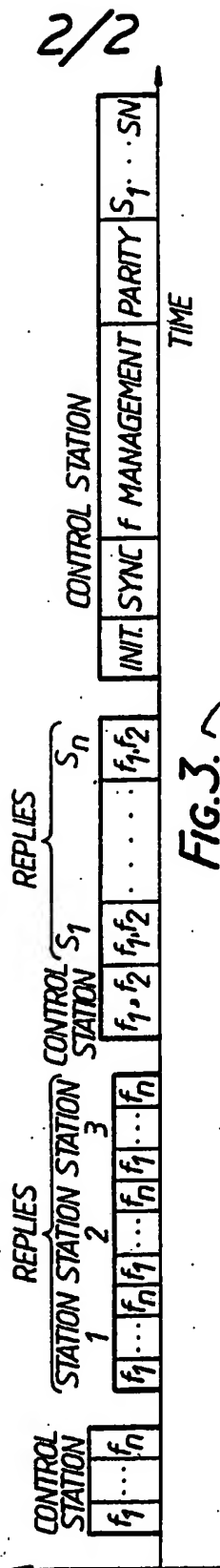
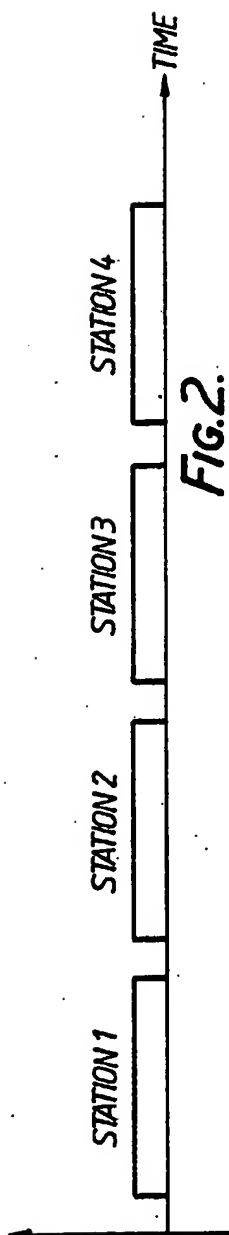


Fig. 1.



INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 87/00822

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁴ : H 04 L 1/12		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁴	H 04 L; H 04 B; H 04 Q	
Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ⁹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	A.F.I.P.S. Conference Proceedings, 1975 National Computer Conference, 19-22 May 1975, Anaheim, California, AFIPS Press, (Montvale, New Jersey, US), J. Burchfiel et al.: "Functions and structure of a packet radio station", pages 245-251 see page 247, left-hand column, lines 8-28	1,2,4,6-9
A	COMPCON '80, 21st IEEE Computer Society International Conference, Washington, D.C., 23-25 September 1980, IEEE, (New York, US), J.W.S. Liu: "Distributed routing and relay management in mobile packet radio networks", pages 235-243 see page 235, right-hand column, lines 28-34	1,2,6-9
A	ICC '79 Conference Record, International Conference on Communications, Boston,	1,2,6-9
<p>* Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
28th January 1988		20 FEB 1988
International Searching Authority		Signature of Authorized Officer
EUROPEAN PATENT OFFICE		P.C.G. VAN DER PUTTEN

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
	<p>MA., 10-14 June 1979, IEEE, (New York, US), F.J. Ricci: "Packet distribution system in a survivable satellite network", pages 41.1.1 - 41.1.5 see page 41.1.1, right-hand column, lines 5,6</p> <p>-----</p>	